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SSALTO

ALGORITHM DEFINITION, ACCURACY AND SPECIFICATION VOLUME 1: JASON REAL TIME PROCESSING

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3	0	14th April 2000	Minor update (removal of the interpolation of COG and USO frequency to the altimeter time tags)	

ABBREVIATIONS

Abbreviation	Definition
ADA	Algorithm Definition and Accuracy
ADx	Applicable Document x
AGC	Automatic Gain Control
CLS	Collecte Localisation Satellites
CMA	Centre Multi-missions Altimétrique
CNES	Centre National d'Etudes Spatiales
COG	Center of Gravity
DAD	Dynamic Auxiliary Data
FFT	Fast Fourier Transform
GDR	Geophysical Data Record
IGDR	Interim Geophysical Data Record
JMR	JASON Microwave Radiometer
JPL	Jet Propulsion Laboratory
LPF	Low-Pass Filter
LS	Least Square
LTM	Long Term Monitoring
NRT	Near Real Time
OFL	Off-Line

Abbreviation	Definition
PF	Platform
PTR	Point Target Response
RMS	Root Mean Square
RDx	Reference Document x
Rx	Reception path
SAD	Static Auxiliary Data
SNR	Signal to Noise Ratio
SSALTO	Segment Sol Altimétrie et Orbitographie
SSPA	Solid State Power Amplifier
SWH	Significant Waveheight
SWT	Science Working Team
TEC	Total Electron Content
TBC	To Be Confirmed
TBD	To Be Defined
Tx	Transmission path
USO	Ultra-Stable Oscillator
UTC	Universal Time Coordinate

APPLICABLE AND REFERENCE DOCUMENTS

Reference	Document title
TP2-SB-J0-102-CNES	AD1 JASON-1 Science and Operational Requirements
SMM-ST-M2-EA-10658-CN	AD2 CMA Requirements Specification
SMM-ST-M-EA-10879-CN	AD3 SSALTO Products Specifications - Volume 1: JASON-1 User Products
TP2-SB-J0-459-CNES	AD4 JASON-1 Products Description
SMM-MIF-M-EA-20054-CN	AD5 Manuel des Interfaces
SMM-ST-M1-EA-20078-CN	AD6 POSEIDON-2 Level 1.0 Altimeter data product
SMM-ST-M1-EA-31023-CLS	AD7 JMR Level 1.0 data product
SMM-IF-M/JALT-EA-11870-CN	AD8 Spécifications d'interface entre SSALTO et les experts altimètre
SMM-IF-M/JRAD-EA-11871-CN	AD9 Interface specifications between SSALTO and the radiometer experts
SMM-IF-M2-EA-20207-CN	AD10 SSALTO internal Interfaces specification : CMA (CAL & TEC products)
SMM-ST-M2-EA-11003-CN	AD11 Algorithm Definition, Accuracy and Specification Volume 2: CMA Altimeter Level 1b Processing
SMM-ST-M2-EA-11004-CN	AD12 Algorithm Definition, Accuracy and Specification Volume 3: CMA Radiometer Level 1b Processing
SMM-ST-M2-EA-11005-CN	AD13 Algorithm Definition, Accuracy and Specification Volume 4: CMA Altimeter Level 2 Processing
SMM-ST-M2-EA-11010-CN	AD14 Algorithm Definition, Accuracy and Specification Volume 9: CMA Mechanisms
SMM-SP-M2-EA-32012-CLS	RD1 CMA production: Specifications of the Data management Algorithms

TBD	RD2 TBD (Features of the thermal control of the platform)

TBC AND TBD LIST

TBC/TBD	Section	Brief description
TBD	Reference documents	Nomenclature and title of RD2

CONTENTS

1. INTRODUCTION

This document is aimed at defining and specifying the main functions of the nominal Near Real Time (NRT) processing of the JASON-1 altimeter (POSEIDON-2) and radiometer (JMR) data.

Regarding the JASON-1 mission, the highest level requirements placed by the JASON Science Working Team upon the JASON project to meet the scientific and operational objectives of the mission are listed in AD1, and the requirements aimed at defining the CMA facility inside the SSALTO system are established in AD2.

From the description of JASON-1 products given in AD4, the NRT processing may be viewed as the following three procedures:

- The Altimeter Level 1b NRT processing. It is constituted by a subset of the algorithms of the ALT processing. The ALT processing is defined in AD11. It is aimed at providing the POSEIDON-2 level 1b parameters, i.e. the altimeter parameters with instrumental and internal calibration corrections applied, from the level 1.0 POSEIDON-2 parameters, using in particular the outputs of the long term monitoring of the level 1b POSEIDON-2 internal calibration data.
- The Radiometer Level 1b processing (RAD processing), which is aimed at providing the JMR level 1b parameters, i.e. the brightness temperatures with instrumental and internal calibration corrections applied, from the level 1.0 JMR parameters. It is defined in AD12.
- The Altimeter/Radiometer Level 2 NRT processing. It is constituted by a subset of the algorithms of the IGDR processing. The IGDR processing is defined in AD13. It is aimed at providing level 2 parameters from POSEIDON-2/JMR level 1b parameters, using restituted auxiliary data (meteorological fields, pole location, DORIS ionospheric data) and a DORIS preliminary orbit.

As previously mentioned, this document deals with both the definition of the NRT procedures and the specification of their main functions.

Definition of the NRT procedures

The definition of the NRT procedures consists of the identification and the description of their main functions. It will provide the reader with an overview of the procedures and a global understanding of the algorithms.

Specifications of the NRT procedures

Regarding the specifications of the NRT procedures, two kinds of algorithms are distinguished :

- The “scientific” algorithms, which represent the core of the processing
- The other algorithms, which will be called the “data management” algorithms, ensuring functions such as :
  - To get the input data
  - To prepare the data to be processed (for example to select the orbit data set requested to compute the location of each altimeter measurement)
  - To perform unit conversions or changes in reference systems
  - To perform general checks (relevant for example to the presence of input files, to the data conformity or to the computability of input data with the data set to be processed)
  - To build the output product(s)
  - To manage the processing

The scientific algorithms are specified in this document and in AD14 for the mechanisms, which represent the functions common to several algorithms or the functions frequently requested within an algorithm. The data management algorithms, which strongly depend on the format of the input and output data, are specified in RD1 (and AD14 for the corresponding mechanisms, if any). The complete set of specifications (to be associated with the corresponding interfaces documents) are intended for the team in charge of the software development.

Conventions

The NRT procedures are represented in this document as linear sets of functions which are aimed at building a set of NRT parameters from a set of level 1.0 parameters. This representation has been chosen for historical reasons in order to ease the understanding of the overall procedures, but it does not anticipate the organization or the sequencing of the algorithms within the CMA processor.

As the algorithms identified in this document are identical to the ones given in AD11, AD12 and AD13, they will not be repeated here in detail but instead, reference to the document in which they appear will be made. If differences appear between an algorithm of the NRT processing and its equivalent of the OFL processing, they will be described in detail. Thus, for a good understanding of this processing the reader is invited to read documents AD11, AD12 and AD13. To keep coherency between this document and AD11, AD12 and AD13, we will use the same wordings.

Organization of the document

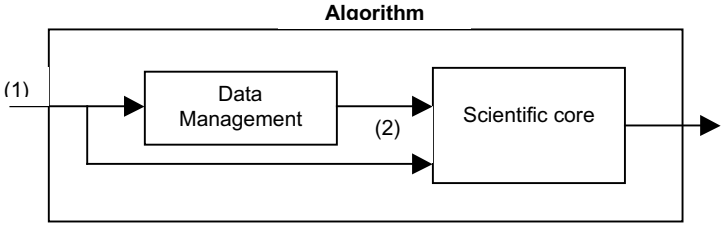
- The product tree pointing out the main features of the JASON-1 NRT procedures (grey cells) and of the corresponding output data levels is given in **Figure 1**.
- The interfaces of the procedures (input and output data) are defined in § 2.
- The Altimeter Level 1b NRT processing algorithms are described in § 3.
- The Radiometer Level 1b processing algorithms are described in § 4.
- The Altimeter Level 2 NRT processing algorithms are described in § 5.

For each one of these three procedures, the description consists of:

- An overview of the overall processing (brief description of the processing and list of functions).
- The definition and the specification of the algorithms, using the following items :
  - Name and identifier of the algorithm
  - Heritage
  - Function
  - Applicability to the various procedures
  - Algorithm definition :
    - Input data
    - Output data
    - Mathematical statement
  - Algorithm specification :
    - Input data
    - Output data

- Processing
- Accuracy (if any)
- Comments (if any)
- References (if any)

As previously mentioned, only the scientific core of each algorithm is specified in this document. For each algorithm, the input data (1) identified in the "Algorithm definition" section corresponds to the input data required for the global processing (Data Management and Scientific Core), while the input data (2) identified in the "Algorithm specification" section corresponds to the data requested for the scientific core only.



The general information necessary for a global understanding of the algorithm within the overall processing is provided in the “Algorithm definition” sections.

The detailed information required by the team in charge of the software development is provided in the “Algorithm specification” sections, which precisely define the scientific part (i.e. the core) of the algorithms.

Basic rules

The following basic rules are applied to the specification of the algorithms:

- The specifications of an algorithm are always relevant to the processing of a single data point and not to a set of data points
- Elementary functions which are common to several algorithms (also called “mechanisms”) are specified in AD14.
- The input and output data are always identified by a precise description, an explicit name (that could be used in the coding phase), a unit and, if necessary, a reference system
- Regarding the errors that may occur during the processing functions (for example, negative argument for logarithmic or square root functions), the algorithms systematically output an execution status. The building and the management of this information will be defined during the architectural design of the software.
- Regarding the representation of tables, the following conventions are used in the following:
  - $X[N_1:N_2]$ represents a one-dimension table whose elements are X(i) (or X_i) with $i \in [N_1, N_2]$
  - $X[N_1:N_2][M_1:M_2]$ represents a two-dimension table whose elements are X(i,j) (or X_{ij}) with $i \in [N_1,N_2]$ and $j \in [M_1,M_2]$
  - And so on

Terminology

In this document, an altimeter "elementary measurement" refers to each individual measurement performed every 50 ms for POSEIDON-2 in nominal tracking operation. An "averaged measurement" refers to the compression of 20 elementary measurements (every 1s for POSEIDON-2). The elementary measurements are sometimes also referred to as the 20 Hz measurements, and the averaged measurements are sometimes also referred to as the 1

Hz measurements. There is no ambiguity about radiometer measurements which are averaged measurements only (approximately every 1 second for the JMR).

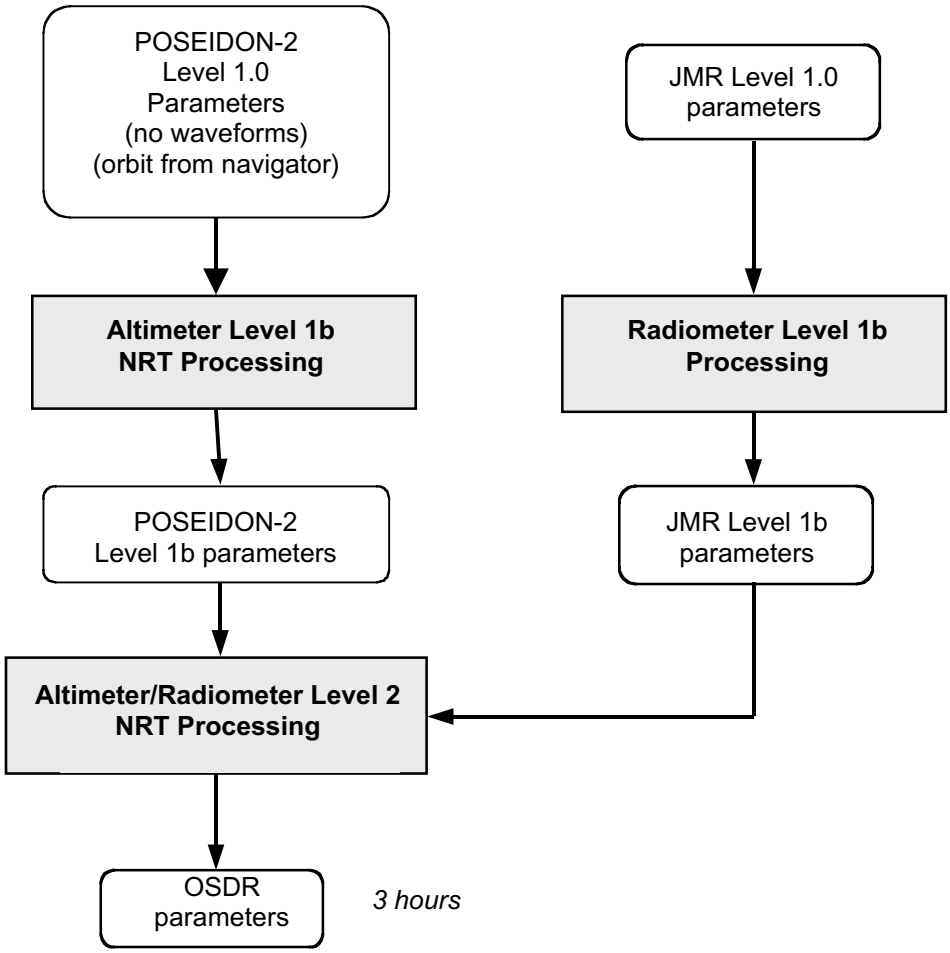


Figure 1: Product tree (JASON-1 NRT processing)

The JASON-1 NRT processing is represented in this document as a set of three procedures: one for the Altimeter Level 1b NRT processing, one the Radiometer Level 1b processing and one for the Altimeter/Radiometer Level 2 NRT processing. This representation has been chosen for historical reasons (see AD11, AD12 and AD13) in order to ease the understanding of the overall procedures, but it does not anticipate the organization or the sequencing of the algorithms within the CMA processor.

2. INPUT AND OUTPUT DATA

2.1. INPUT DATA

Two types of input data may be discriminated (see AD2):

- "Product" data, which correspond to measurements performed by the altimeter or the radiometer instruments:
  - POSEIDON-2 level 1.0 parameters, for Altimeter Level 1b NRT processing
  - JMR level 1.0 parameters, for Radiometer Level 1b processing
  - POSEIDON-2 / JMR level 1b parameters, for Altimeter/Radiometer Level 2 processing
- Auxiliary data, which may be dynamic or static:
  - Dynamic auxiliary data (DAD) are the time-varying data
  - Static auxiliary data (SAD) are constant data.

For the above NRT procedures, the altimeter or radiometer dataset on input represents a sequential set of measurements.

2.1.1. PRODUCT DATA

- JASON-1 POSEIDON-2 level 1.0 parameters:

  These parameters are described in AD6.

- JASON-1 JMR level 1.0 parameters:

  These parameters are described in AD7.

- JASON-1 POSEIDON-2 and JMR Level 1b parameters:

  The JASON-1 POSEIDON-2 Level 1b parameters consist of the POSEIDON-2 level 1.0 parameters required on input of the level 2 processing and of the parameters computed by the POSEIDON-2 level 1b algorithms (see AD11).

  The JASON-1 JMR Level 1b parameters consist of the JMR level 1.0 parameters required on input of the level 2 processing and of the parameters computed by the JMR level 1b algorithms (see AD12).

  These parameters are considered as intermediate parameters within a global processing of the altimeter and radiometer measurements from level 1.0 (see AD6 for the altimeter and AD7 for the radiometer) to IGDR (see AD3).

2.1.2. AUXILIARY DATA

- **Dynamic auxiliary data:**

  Dynamic auxiliary data for JASON NRT processing consist of:

  - Platform data (distance antenna-COG), described in AD5
  - DORIS-derived data (USO frequency), described in AD5

– POSEIDON-2 LTM calibration parameters (features of the PTR and of the LPF), described in AD10

The dynamic auxiliary data required on input of the NRT processing must be the data that at least cover the time span of the input dataset to be processed.

- **Static auxiliary data:**

Static auxiliary data for JASON level 1b procedures consist of:

– The following POSEIDON-2 features, described in AD8:

  * POSEIDON-2 instrumental characterization data
  * Instrumental corrections tables, built from a simulator of the altimeter and of the on-board retracking algorithm, accounting in particular for all the instrumental features provided by the POSEIDON-2 internal calibration (PTR and LPF)

– The JMR instrumental characterization data, described in AD9

– The following data, described in AD10:

  * Universal constant data
  * Processing parameters (all the constant parameters used in the processing, such as thresholds, etc)
  * Land/sea mask
  * Sea State Bias table
  * Wind table

2.2. OUTPUT DATA

It is assumed that the NRT processing does not modify the organization of the input data. Therefore, level 1b processing outputs one set of level 1b parameters that is structured identically to the set of input parameters. The same holds for the output of the level 2 processing.

The JASON-1 altimeter/radiometer level 1b parameters are described in section 2.1.1.

The JASON-1 altimeter/radiometer level 2 parameters are described in AD3.

2.3. SUMMARY OF THE INTERFACES

The interfaces of the JASON-1 Altimeter Level 1b NRT, Radiometer Level 1b and the Altimeter/Radiometer Level 2 procedures are summed up in **Figure 2**.

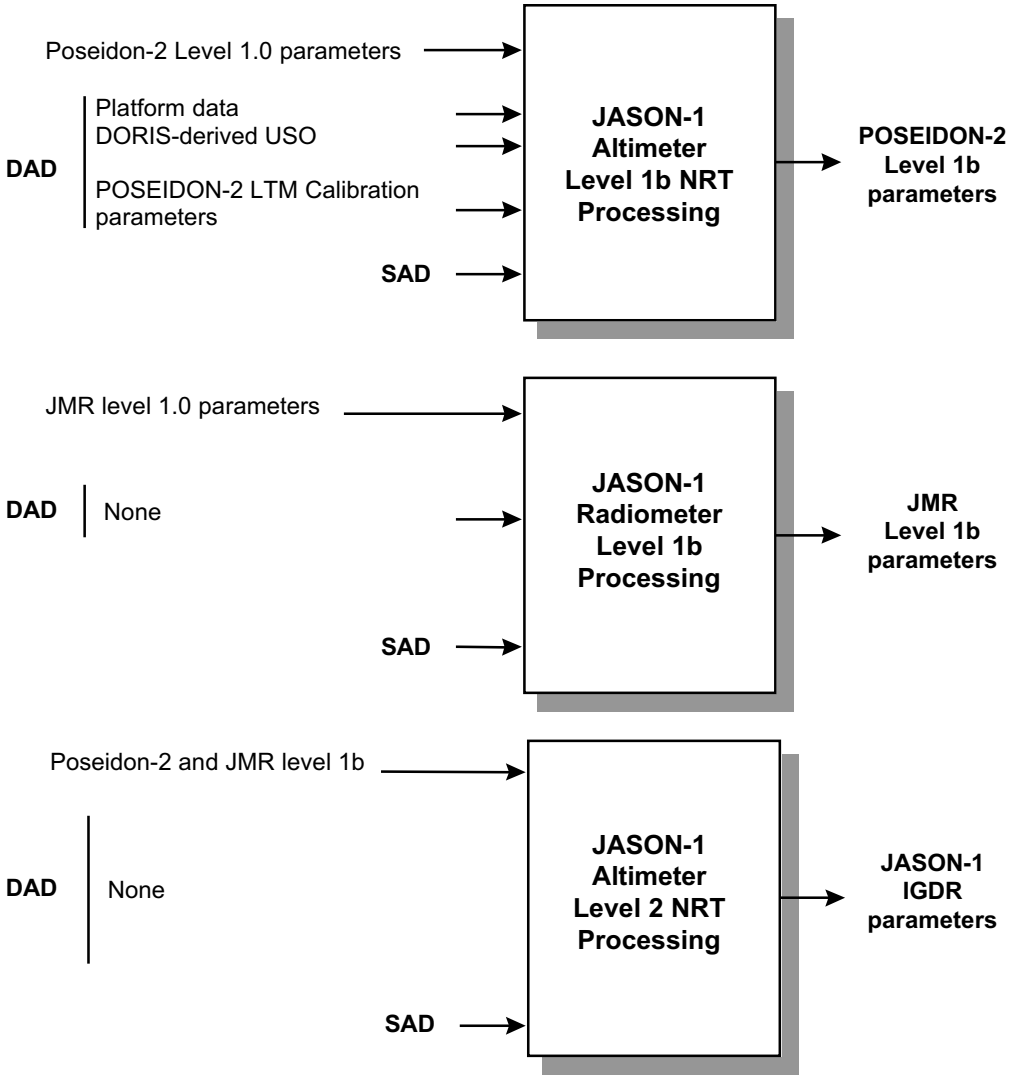


Figure 2: Interfaces of the JASON-1 NRT processing

3. ALTIMETER LEVEL 1B NRT PROCESSING

3.1. PROCESSING OVERVIEW

3.1.1. BRIEF DESCRIPTION

A brief overview of the functions of the Altimeter Level 1b NRT processing is given in this section. A detailed description is provided in § 3.2.

- The type of the overflown surface (4 states) is determined from a land/sea mask file.
- For each elementary measurement, the coarse and fine trigger delays applied on-board to each pulse (Ku or C bands) are restored from the level 1.0 tracker range and tracker range rate.
- For each elementary measurement, the Ku-band and C-band tracker range estimates are computed from the restored coarse and fine trigger delays, accounting for the DORIS USO frequency drift. Moreover, the tracker range rate is converted into distance versus time.
- The on-board retracked estimates of the altimeter range are then derived for Ku and C bands, using the on-board epoch estimates in both bands.
- The elementary Ku-band and C-band AGC values are corrected for the instrumental errors due to the imperfections of the on-board attenuators.
- The square of the off-nadir angle is derived from the 1-Hz on-board estimates of the total power of the Ku-band waveforms in two windows set on the trailing edge, accounting for the effect of the low-pass filter (POSEIDON-2 LTM calibration parameters).
- The following elementary estimates are edited and compressed over 1 second:
  - tracker ranges (Ku and C bands)
  - tracker range rates
  - on-board retracked altimeter ranges (Ku and C bands)
  - corrected AGC (Ku and C bands)

  Moreover, 1-Hz estimates of the on-board-waveform-derived square of the off-nadir angle are computed by an averaging over $N \geq 1$ seconds.
- The 1-Hz so-called "scaling factor for on-board retracked Sigma0 evaluation" requested to determine the backscatter coefficients from the on-board estimates of the AGC combined with the retracked amplitude of the waveforms, is computed for the Ku and C bands. These parameters account for the total power of the altimeter PTR (POSEIDON-2 LTM calibration parameters).
- The Ku-band and C-band on-board retracked backscatter coefficients are computed from the 1-Hz scaling factors for Sigma0 evaluation and from the 1-Hz on-board estimates of the AGC combined with the retracked amplitude of the waveforms.
- The signal to noise ratio (Ku and C bands) is computed from the 1-Hz on-board estimate of the AGC combined with the retracked amplitude, the 1-Hz corrected AGC and the 1-Hz thermal noise level estimates.
- The 1-Hz corrections of the impact of an antenna mispointing on the altimetric estimates (altimeter range, significant waveheight and backscatter coefficient) are computed for Ku and C bands from models depending on the significant waveheight, and on the square of the off-nadir angle (computed from waveform-derived data).

- The 1-Hz modeled corrections of the instrumental errors on the altimetric estimates (altimeter range, altimeter range rate, significant waveheight and backscatter coefficient) are computed for Ku and C bands, using correction tables (see § 2.1.2) depending on the significant waveheight and on the signal to noise ratio.
- The 1-Hz internal path correction on the altimeter range is computed, accounting in particular for the difference of travel between the transmission and the reference lines within the altimeter (POSEIDON-2 LTM calibration parameter).
- The 1-Hz Doppler correction on the altimeter range is computed for Ku and C bands from the orbital altitude rate with respect to the reference ellipsoid, derived from DORIS navigator orbit (level 1.0 parameter). This correction does not take into account that the spacecraft overflows a surface with varying height. It is sufficient for the NRT error budget.
- The Ku and C bands corrected parameters (tracker ranges, tracker range rates, on-board retracked altimeter ranges, on-board retracked significant waveheights and on-board retracked backscatter coefficients) are computed, accounting in particular for the distance antenna - COG and for system biases (aimed at providing data sets consistent with data sets issued from a reference mission: e.g. TOPEX).

Thanks to the features of the thermal control of the platform (see RD2), temperatures of the altimeter components (housekeeping data) are not required in the processing of the altimeter data. The interpolation of the total power of the PTR versus the SSPA temperature, which was performed in the processing of the POSEIDON-1 data, was justified because of the frequent switches on and off of the altimeter.

3.1.2. LIST OF FUNCTIONS

A list of the functions of the JASON-1 Altimeter Level 1b NRT processing is given in **Figure 3.**

The functions defined hereafter only concern altimeter measurements in tracking mode.

FUNCTION
GEN_ENV_SUR_01 - To determine the surface type
ALT_PHY_RAN_01 - To restore the on-board coarse and fine trigger delays
ALT_PHY_RAN_02 - To compute the tracker ranges
ALT_PHY_RAN_03 - To compute the on-board retracked altimeter ranges
ALT_PHY_BAC_01 - To correct the AGC
ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates
ALT_COM_RAN_01 - To edit and compress the tracker ranges
ALT_COM_RAN_03 - To edit and compress the tracker range rates
ALT_COM_RAN_04 - To edit and compress the on-board retracked altimeter ranges
ALT_COM_BAC_01 - To edit and compress the corrected AGC
ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived)
ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation
ALT_PHY_BAC_03 - To compute the on-board retracked backscatter coefficients
ALT_PHY_SNR_01 - To compute the SNR from the on-board estimates
ALT_COR_GEN_01 - To compute the mispointing corrections
ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters
ALT_COR_RAN_01 - To compute the internal path correction
ALT_COR_RAN_02 - To compute the Doppler correction
ALT_COR_RAN_03 - To compute the corrected tracker ranges
ALT_COR_RAN_04 - To compute the corrected on-board retracked altimeter ranges
ALT_COR_RAN_05 - To compute the corrected tracker range rates
ALT_COR_SWH_01 - To compute the corrected on-board retracked significant waveheights
ALT_COR_BAC_01 - To compute the corrected on-board retracked backscatter coefficients

Figure 3: Functions of the JASON-1 Altimeter Level 1b NRT processing

3.2. FUNCTIONS

The detailed description of the functions of the nominal JASON-1 Altimeter Level 1b NRT processing is given in AD11.

Regarding the computation of the mispointing corrections, be aware that in the real time processing, the corrections will be computed from the off-nadir angle estimate derived from the waveforms, because platform data are not available.

4. RADIOMETER LEVEL 1B PROCESSING

4.1. PROCESSING OVERVIEW

The Radiometer processing for the NRT process is strictly identical to the one given in AD12.

4.1.1. BRIEF DESCRIPTION

A brief overview of the main functions of the JMR processing is given in this section. A more detailed description is provided in section 4.2.

- The surface type overflown by the three radiometer channels is determined accounting for the antenna diagram characteristics.
- The main beam brightness temperature is computed for each channel from antenna temperature (correction of antenna pattern)
- For each channel, the main beam brightness temperatures are averaged along-track to equalize the different channel footprints along the satellite ground track.

4.1.2. LIST OF FUNCTIONS

A list of the functions of the JASON-1 Radiometer Level 1b NRT processing is given in **Figure 4**.

FUNCTION
GEN_ENV_SUR_03 - To determine the JMR surface type
RAD_PHY_TEM_01 - To compute the main brightness temperatures
RAD_COM_TEM_01 - To equalize the channels footprints along the spacecraft groundtrack

Figure 4: Functions of the JASON-1 Radiometer Level 1b NRT processing

4.2. FUNCTIONS

The detailed description of the functions of the JASON-1 Radiometer Level 1b processing is given in AD12.

5. ALTIMETER/RADIOMETER LEVEL 2 NRT PROCESSING

5.1. PROCESSING OVERVIEW

5.1.1. BRIEF DESCRIPTION

A brief overview of the functions of the level 2 procedures for the NRT process is given in this section. A detailed description is provided in § 5.2.

- The radiometer brightness temperatures (3 channels) and associated flags are interpolated to the 1-Hz altimeter time-tags.
- Then, the JMR geophysical parameters (wet tropospheric correction, water vapor and cloud liquid water contents, wind speed, Ku-band and C-band backscatter coefficients atmospheric attenuations) are computed from the brightness temperatures.
- The Ku and C bands ocean backscatter coefficients are corrected for the atmospheric attenuation and the 10-meter altimeter wind speed is derived (from the Ku-band estimate).
- The sea state bias is computed for the 1-Hz ranges from the Ku and C bands.
- The dual-frequency ionospheric correction is computed for the 1-Hz ranges from the Ku and C bands

5.1.2. LIST OF FUNCTIONS

A list of the functions of the JASON-1 Altimeter/Radiometer Level 2 NRT processing is given in **Figure 5**.

The functions defined hereafter only concern altimeter measurements in tracking mode.

FUNCTION
RAD_MAN_INT_01 - To interpolate radiometer data to altimeter time tags
RAD_PHY_GEN_01 - To compute the JMR geophysical parameters
ALT_PHY_WIN_01 - To correct the backscatter coefficients for atmospheric attenuation and to compute the 10 meter altimeter wind speed
ALT_COR_RAN_10 - To compute the sea state biases
ALT_COR_RAN_12 - To compute the dual-frequency ionospheric corrections

Figure 5: Functions of the JASON-1 Altimeter/Radiometer Level 2 NRT processing

5.2. FUNCTIONS

The detailed description of the functions of the JASON-1 Altimeter/Radiometer Level 2 NRT processing is given in AD13.

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